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The Acoustic Vowel Space of Central Minnesota English: Focus on Female Vowels

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THE ACOUSTIC VOWEL SPACE OF CENTRAL MINNESTOTA ENGLISH: FOCUS ON FEMALE VOWELS[1]

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ABSTRACT

This study is the first of its kind devoted to the acoustic vowel space of the dialect of American English spoken by female residents of Central Minnesota. It uses the methodology that Peterson and Barney (1952) used in their landmark study of General American English (GAE). Hillenbrand et al. (1995) used the same methodology to study Midwest vowels. The present study is based on 12 vowels produced by 22 female college students who grew up in one of the nine counties of Central Minnesota. The study highlights three important ways in which Central Minnesotan vowels differ from vowels produced by those in other parts of the country. First, in Central Minnesota / æ / has two pronunciations. It is pronounced / æ / everywhere else, except when it occurs before / g /. In this context, it is pronounced / ɛ /. This pronunciation causes people who are not familiar with Central Minnesota English (CMnE) to be confused as to whether the speaker intends to say <bag> or <beg>. The second way in which the dialect of this area differs from GAE and Midwest English (MWE) is the complete merger of / a / and / ɔ /. Therefore, the phonemic inventory of CMnE vowels is reduced to 11 instead of the 12 that we see in other dialects. Finally, the last major change underway concerns the vowel / ʊ /. When the female[2] residents of Central Minnesota produce it, they open their mouths a little wider and do not round their lips enough. As a result, their / ʊ / ends up sounding more like / ʌ /.

1.0 Introduction

Authorities on English dialects have devoted most of their scholarship to vowels rather than to consonants. Ladefoged (2006:38) explains why this is so: "Accents of English differ more in their use of vowels than in their use of consonants." For this reason, the present study also deals with vowels, and more specifically with female vowels. It is carried out to see how the vowels in CMnE female vowels differ from female vowels in GAE and MWE. To achieve this goal, I borrowed methodologies from three sub-disciplinary strands within linguistics. Since the overall study qualifies as a sociolinguistic investigation, the main methodological framework used is that of variationist sociolinguistics. The second linguistic discipline that contributes to the

[1] When I presented an earlier version of this paper at the Linguistic Colloquium at the University of Minnesota, some in the audience felt that the findings reported here could apply to the Twin Cities of Minneapolis and Saint Paul, and probably to a large portion of the state of Minnesota. This may indeed be the case. However, since the data comes only from Central Minnesota, no generalization will be made. I'm indebted to all the linguists and linguistics students who came to the presentation and enthusiastically shared their views on this topic. A special note of thanks to **Professor Emeritus Bruce Downing** who graciously accepted to eat dinner with me after the presentation for an extended conversation over my findings.

[2] Numerous sociolinguistic studies have indicated that women are ordinarily at the forefront of phonetic changes. However, this is not the reason why this study focuses on women. It happens that I have more female data than male data.

methodology of this paper is acoustic phonetics. It is used because it helps to measure and quantify the extent to which CMnE vowels vary from those of GAE and MWE. Finally, a phonological methodology is used because the classification of the types of variations observed in CMnE is in accordance with the labels given to phonological processes involving vocalic changes. The advantage of examining CMnE from multiple sub-disciplinary lenses is that it helps answer the central question of this study, that is, do the variations observed in CMnE impinge on mutual intelligibility with GAE and MWE?

2.0 Geographical Location of the Study

The region referred to in this paper as "Central Minnesota" is an administrative entity consisting of nine counties: Aitkin, Benton, Crow Wing, Kanabec, Morrison, Sherburne, Stearns, Todd, and Wadena. A circle has been drawn around these counties, as shown on the map below:

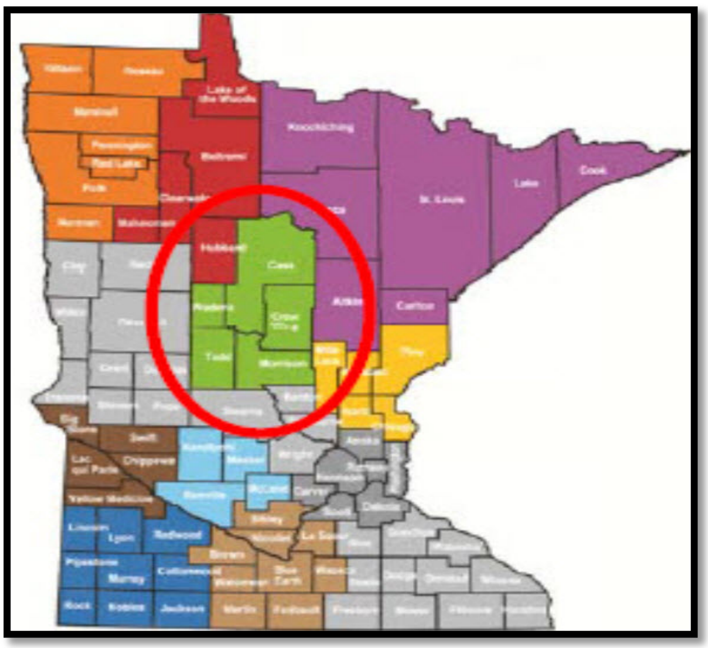

Figure 1: Map of Central MN[3]

The main towns of the area are Brainerd, Little Falls, Saint Cloud, and surrounding towns.

The region is fairly homogeneous racially. Census data indicates that racial minorities make up only 6% of the population, compared with the state's average of 11.8%.[4] Over the last few decades, the population of the area has grown tremendously. In 1900, there were barely 10,000 people in Central Minnesota. A century later, that is, in 2010, 350,000 people made Central Minnesota their home. In 2030, the population of the area is projected to be 500,000. The minority presence is also growing steadily.

[3] The state of Minnesota demographic databank is found at: http://images.google.com/. The information was retrieved on March 8, 2013.

[4] http://www.gda.state.mn.us/ListeningPosts/2002_pdf_files/lp2-Region7W.pdf, retrieved on March 8, 2013.

However, much of the diversity is confined to Saint Cloud and surrounding communities because they host Saint Cloud State University, the College of Saint Benedict, Saint John's University, and Saint Cloud Community and Technical College. These four institutions of higher education have attracted minority faculty, staff, and students to Central Minnesota. There are also industries in the area that employ many minorities.

3.0 Past Studies of Acoustic Vowel Spaces

In 1952, Peterson and Barney conducted a nationwide acoustic phonetic study of the vowels of GAE. They recruited 76 participants from all over the United States of America: 33 men, 28 women, and 15 children. It was truly a groundbreaking study because it made it possible to quantify and plot GAE vowels in an acoustic vowel space. Forty-three years later, in 1995, Hillenbrand et al. replicated Peterson and Barney's seminal study. Their study had 139 participants: 45 men, 48 women, and 46 children. The participants came from all over the Midwest, but the largest contingent, 89%, was from Michigan's lower peninsula. Hillenbrand et al.'s study is useful for a study of CMnE vowels because it included [e] and [o], which Peterson and Barney had excluded on the assumption that they were diphthongs, not monophthongs. Collectively, the two studies investigated the acoustic properties of the 12 vowels found in the following words <*heed, hid, hayed, head, had, hod, hawed, hoed, hood, who'd, hud, heard*>. All the words in the list began with / h / for the following reason:

> One of the other sounds of English which is interesting to discuss is the sound which is usually written with the letter *h*. In this sound the vocal folds are not in action as they are when we say a vowel; nor is there any acoustic energy generated by forcing air though a narrow gap. Instead the air from the lungs has a relatively free passage out though the vocal tract. But whenever an airstream passes through the vocal cavities, some small variations in air pressure will be caused by the irregular surfaces which obstruct the flow; and these pressure variations will be sufficient to produce very slight vibrations of the body of the air in the vocal tract. As the positions of the articulators during the sound [h] are similar to those of the surrounding sounds, such as the adjacent vowels, the frequency components in [h] sounds have relative amplitudes similar to those in vowels; but the complex wave has a smaller amplitude and no fundamental frequency, as it is not generated by regular pulses from the vocal cords (Ladefoged 1996:112).

Small (2005:136) provides a more succinct explanation, namely, "During the production of / h /, the articulators will take the shape of whichever vowel follows." All the words in the list end with / d / because in acoustic phonetic investigations, it is crucially important that the vowels being studied occur in identical environments. Since the acoustic vowel space of CMnE is a replication study, it goes without saying that I follow scrupulously the methodological paradigms that have been set forth in the two previous landmark studies.

4.0 The Central Minnesota Study

The current study is based on the pronunciation of 22 female students who were born and raised in one of the nine counties of Central Minnesota. The participants were all enrolled in English 473/573, a Laboratory Phonology course that I teach at Saint Cloud State University. The data was collected over a seven-year period, from 2005 to 2012. The students signed an Institutional Review Board (IRB) consent form allowing me to use their vowel data for this study. All the participants in the present study are Caucasians in their late teens to their early 30s. Male vowel data from Central Minnesota is available and will be described in a sequel study.

Each participant recorded herself producing each word three times, for a total of 792 repetitions (12 x 3 x 22). Unlike Peterson and Barney (1952) and Hillenbrand et al. (1995) who included <heard> in their study, the CMnE study excludes <heard> because the vowel [ɚ] is not a phoneme, but only an allophone. Instead, <heard> is replaced with <hag>. The reason for including <hag> is to examine and quantify the amount of vowel raising in Central Minnesota. Table 1 displays and compares CMnE female vowels with those of GAE and the Midwest:

Words		heed	hid	hayed	head	had	hod	hawed	hoed	hood	who'd	hud	hag
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]	[æ]
GAE	F1	310	430	NA	610	860	850	590	NA	470	370	760	NA
GAE	F2	2790	2480	NA	2330	2050	1220	920	NA	1160	950	1400	NA
MWE	F1	437	483	536	731	669	936	781	555	519	459	753	NA
MWE	F2	2761	2365	2530	2058	2349	1551	1136	1035	1225	1105	1426	NA
CMnE	F1	385	573	508	754	848	855	851	569	626	417	743	655
CMnE	F2	2609	2232	2487	2028	1951	1462	1420	1117	1519	1230	1643	2298

Table 1: Comparative Acoustic Vowel Spaces of Female Talkers

The vowels of these three dialects are plotted in the same acoustic vowel space so as to show how they relate to each other. They are also normalized. Thomas (2011:160) explains that "vowel normalization is often necessary for meaningful linguistic and sociolinguistic comparisons when you're examining the vowel realizations of different speakers acoustically." The normalization method used in this paper is "Labov ANAE with Telesur G." It is the same method that was used in the Phonological Atlas of North American English. The results of the normalization and the plotting are in Figure 2:[5]

[5] The following legend is used: the circle represents Central Minnesota Vowels, the squares/rectangles are Midwest vowels, and triangles are used for GAE vowels. For those reading the digital version, the red represents Central Minnesota vowels, the blue Midwest vowels, and the green GAE vowels.

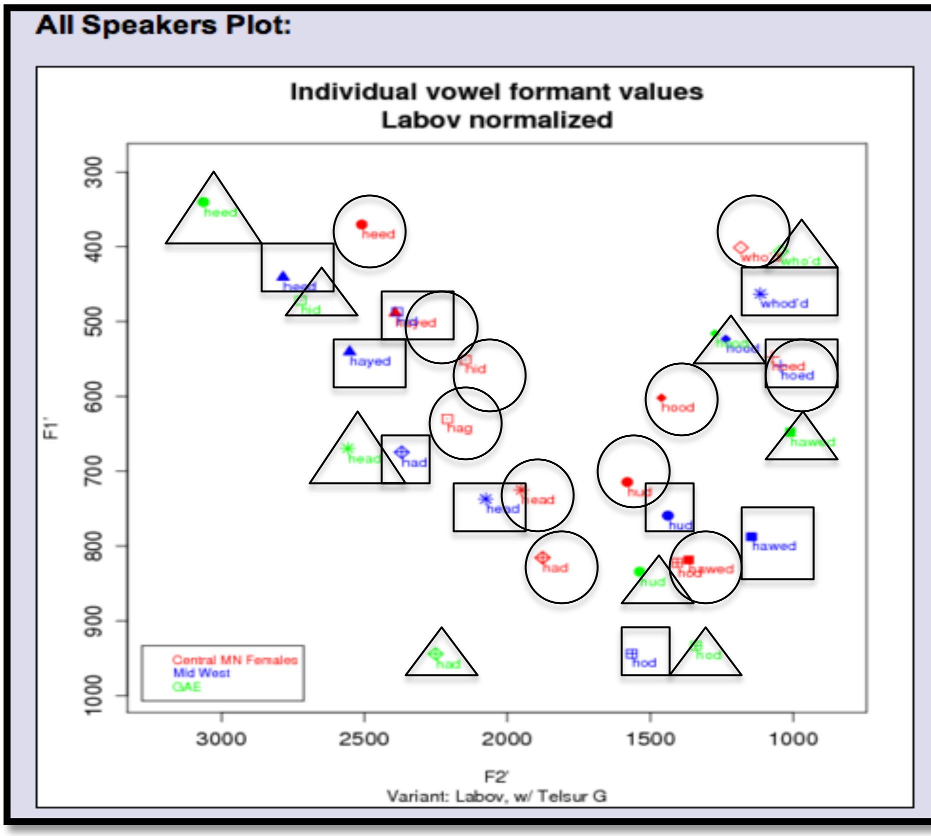

Figure 2: Comparative Vowel Spaces

Ladefoged (2001:43) recommends plotting the vowels of different dialects in the same acoustic vowel space because “vowel charts provide an excellent way of comparing different dialects of a language.” He also writes that, “This kind of plot arranges vowels in a similar way to the vowels in the IPA vowel chart. The formant frequencies are spaced in accordance with the Bark scale, a measure of auditory similarity, so that the distance between any two sounds reflects how far apart they sound,” (Ladefoged 2003:130).

5.0 Confusion and Vowel Intelligibility

An important impetus behind the 1952 study of GAE vowels was to improve telephone communication. Peterson and Barney worked for Bell Laboratories. One aspect of their study was to assess how often hearers confuse the vowels produced by talkers. This interest led to the emergence of a new sub-field within acoustic phonetics known as Confusion. Peterson and Barney (1952) pioneered the method for studying vowel confusion. Miller and Nicely (1955) adapted it for studying consonantal confusion. Since then, Confusion has become part and parcel of many acoustic phonetic studies of intelligibility. Table 2 contains the results of Peterson and Barney (1952:182), and Table 3 displays the confusion results of Hillenbrand et al. (1995:3108):

	Perceived Stimuli										
		[i]	[ɪ]	[ɛ]	[æ]	[ɑ]	[ɔ]	[ʊ]	[u]	[ʌ]	[ɚ]
Spoken Stimuli	[i]	99.9	.03				.02				
	[ɪ]	.05	92.8	6.7	.01						.25
	[ɛ]		2.5	87.7	9.2						.49
	[æ]			2.9	96.5					.14	.37
	[ɑ]				.18	87.0	9.8	.67	0	2.2	.06
	[ɔ]					5.7	92.8	.69	.04	.60	.13
	[ʊ]					.15	.49	96.5	.93	1.6	.18
	[u]							.75	99.1		
	[ʌ]				.07	5.2	1.2	1		92.2	.2
	[ɚ]			.22	.05		.02			.01	99.6

Table 2: Peterson and Barney's Vowel Confusion Matrix

	Perceived stimuli													
		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]	[ɚ]	Total
Spoken Stimuli	[i]	99.6	0.1	0.1	0	0	0	0	0	0	0	0	0.1	99.9
	[ɪ]	0	98.8	0.2	0.9	0	0	0	0	0	0	0	0	99.9
	[e]	0.6	0.3	98.3	0.3	0	0.2	0.1	0	0.1	0	0	0	99.9
	[ɛ]	0	0,5	0	95.1	3.7	0.2	0.1	0	0.1	0	0.2	0.1	100
	[æ]	0	0	0	5.6	94.1	0.2	0	0	0	0	0	0	99.9
	[ɑ]	0	0.1	0	0.1	0.3	92.3	3.5	0.1	0.2	0.1	3.3	0	100
	[ɔ]	0	0	0	0	0	13.8	82.0	0	0.1	0.1	3.8	0.2	100
	[o]	0	0	0	0	0	0	0.1	99.2	0.5	0	0	0.2	99.5
	[ʊ]	0	0	0	0.1	0	0	0	0	97.5	1.3	1.0	0	99.8
	[u]	0	0	0	0	0	0	0	0.4	1.9	97.2	0	0.1	99.6
	[ʌ]	0	0	0	0	0	3.7	1.8	0.3	3.2	0.2	90.8	0.2	100.2
	[ɚ]	0.1	0	0	0	0.2	0	0	0	0.2	0	0	99.5	100

Table 3: Hillenbrand et al. Vowel Confusion Matrix

5.1 Instrumental Assessment of Intelligibility

Up until recently, vowel intelligibility was assessed impressionistically by eliciting hearers' judgments as to whether two vowels sounded the same or not. Koffi (2012: 226-228) has argued that intelligibility can be assessed more reliably by using data from formant measurements. This instrumental method is the one that is used here to assess the intelligibility of CMnE vowels. It is generally accepted in acoustic phonetics that the formants of vowels that are worth analyzing are the first five formants. However, not all five are relevant to intelligibility. Formant 5 provides information about the size of the speaker's head and is useless for identifying the vowel that a talker produces (Ladefoged 2006:187). F4 provides some clues about the characteristics of the vocal tract of the talker (Ladefoged 2001:165,171). F3 provides information about the degree of lip rounding. Most acoustic phonetic studies only tangentially refer to F3 because it does not seem to play any significant role in the perception of vowels. Whatever relevance it may have is taken over by F2 (Ladefoged 2006:188). As for F2, it provides information about tongue advancement or retraction. Generally speaking, front vowels have a high(er) F2 formant measurement, back vowels have a low(er) formant value, and central vowels are halfway between. F1 provides information about vowel height. F1 measurements are inversely proportional to height, that is, the higher the F1 measurement, the lower the vowel. Conversely, the lower the F1 value, the higher the vowel. Furthermore, Ladefoged (2006:188) has noted that F1 plays a more salient role in the perception of vowels than F2 because the former has 80% of the total acoustic energy of the vowel. Therefore, F1 can be used reliably to assess vowel intelligibility.

5.2 Functional Load and Intelligibility

Catford (1987) proposed a method for assessing the intelligibility of segments based on their relative functional load. He defined functional load of phonemes, or phonemic contrast, as "the number of pairs of words in the lexicon that it serves to keep distinct" (pp. 89-90). It is used here to help us determine whether CMnE vowels are intelligible or unintelligible to GAE hearers. If the functional load between two phonemes is high, confusion can lead to greater unintelligibility. However, if the functional load is low or marginal, unintelligibility is inconsequential. Table 4 lists the relative functional load of contrasting pairs of vowels in English:

N0	Vowels	Percentages
1.	bit/bat	100
2.	beet/bit	95
3.	bought/boat	88
4.	bit/but	85
5.	bit/bait	80
6.	cat/cot	76
7.	cat/cut	68
8.	cot/cut	65
9.	caught/curt	64
10.	coat/curt	63
11.	bit/bet	54
12.	bet/bait	53
13.	bet/bat	53
14.	coat/coot	51
15.	cat/cart	51
16.	beet/boot	50
17.	bet/but	50
18.	bought/boot	50
19.	hit/hurt	49
20.	beat/beard	47
21.	pet/pot	45
22.	hard/hide	44
23.	bet/bite	43
24.	cart/caught	43
25.	cart/cur	41
26.	boat/bout	40.5
27.	cut/curt	40
28.	cut/cart	38

29.	Kay/care	35
30.	cart/cot	31.5
31.	*here/hair[6]	30
32.	light/lout	30
33.	*cot/caught	26
34.	fire/fair	25
35.	her/here	24
36.	buy/boy	24
37.	car/cow	23
38.	her/hair	21
39.	*tire/tower	19
40.	box/books	18
41.	*paw/pore	15
42.	pill/pull	13.5
43.	pull/pole	12
44.	bid/beard	11
45.	bad/beard	10
46.	*pin/pen	9
47.	*put/putt	9
48.	bad/Baird	8
49.	*pull/pool	7
50.	*sure/shore	5
51.	pooh/poor	5
52.	*cam/calm	4.5
53.	purr/poor	4.5
54.	good/gourd	1

Table 4: Relative Functional Load of Vowels in English

5.3 Acoustic Distance and Intelligibility

The calculation of the acoustic distance between adjacent pairs of vowels is extremely useful in assessing their degree of mutual intelligibility. Johnson (2012:108) describes various acoustic experiments in which the auditory perception of vowels is gradient, that is, the boundary lines are blurred the closer the vowels are to each other. In other words, the smaller the acoustic distance between two adjacent pairs of vowel, the greater the likelihood of confusion. Conversely, the greater the acoustic distance between adjacent vowels, the more distinct they are from each other. This finding has led phoneticians to posit the Perceptual Distance Hypothesis (PDH). Baart (2010:67) writes that worldwide, the optimal distance between two adjacent vowels is 200 Hz. This optimal distance is smaller in GAE because English has more vowels than most languages. When the data in Peterson and Barney (1952) and Hillenbrand et al. (1995) are tallied, the mean acoustic distance between adjacent pairs of vowel phonemes is 118 Hz. Furthermore, the confusion matrices in Tables 2 and 3 underscore the fact that the

[6] Catford uses an asterisk to indicate that phonemic contrast does not exist in some dialects of English.

rate of confusion is higher when the acoustic distance between vowels is 60 Hz or less. It is a well-known fact in acoustic phonetics that human ears cannot detect frequencies below 20 Hz (Ferrand 2007:34, Ladefoged 1996:21). So, when the acoustic distance between two adjacent vowels is less than or equal to 20 Hz, for all practical purposes, the two sounds are perceptually indistinguishable to human ears because they are sub phonic. The **confusion index** can be summarized as follows. If the distance between two vowels is less than or equal to 20 Hz, hearers perceive them as the same, and confusion is **absolute,** and so is unintelligibility. If the acoustic distance ranges from 21 Hz to 40 Hz, confusion is **mild**, and unintelligibility is **moderate**. Confusion is **slight** if the acoustic distance is between 40 Hz to 60 Hz and unintelligibility is **minimal**. Unintelligibility is **marginal** or **null** if the acoustic distance is 61 Hz or higher. So, 60 Hz is the dividing line between intelligible and unintelligible vowels in GAE. Labov et al. (2013:43) also use 60 Hz as the dividing line between a diphthong that has undergone Canadian raising and a diphthong that has not. This dividing line is used advisedly because there is no agreed upon spoken standard dialect in American English. Fromkin et al. (2014:289) are emphatic about this point:

> SAE is an idealization. Nobody speaks this dialect; and if somebody did, we would not know it, because SAE is not defined precisely (like most dialects, none of which are easy to clarify.) Teachers and linguists held a conference in the 1990s that attempted to come up with a precise definition of SAE. This meeting did not succeed in satisfying everyone's view of SAE. SAE was once represented by the language used by national news broadcasters, but today many of them speak a regional dialect or a style of English that is not universally accepted as "standard."

Though there is not an agreed-upon definition of SAE, phoneticians and speech scientists continue to rely on Peterson and Barney (1952) for all kinds of comparisons. Consequently, it is justifiable to assess the intelligibility of CMnE on the basis of the formant frequencies available in GAE.

6.0 Phonological Processes

Phonologists describe pronunciation as a cognitive process of rule implementation that talkers use when speaking. The phonological literature is replete with rules and theories to account for how this mental process operates. However, such rules are not generally based on any measurable or quantifiable data. Ladefoged (2001:166) sees this as a fundamental weakness in phonology, observing that "one of the objectives of any science is to be able to measure the things that are being described so that they can be expressed in terms of valid, reliable, and significant numbers that people can check." Laboratory Phonology, a branch of phonology that uses acoustic phonetics methodology to explain phonological processes, has emerged as a new sub-discipline of linguistics. Its methodology is used in the remainder of this paper to account for three phonological processes that distinguish CMnE vowels from those found in GAE.

6.1 The Raising of [æ] in Central Minnesota

Vowel raising has been an important phonological process in English since the Great Vowel Shift of the 15th Century (Fromkin et al. 2014:342-343). Centuries ago the process affected only tense vowels. However, in its contemporary form, vowel raising is affecting lax vowels. Throughout the country / æ / raising is on the rise. The process may have started with the raising of / æ / to / ɛ / before nasal consonants. In nearly all the dialects of American English, / æ / is raised to / ɛ / immediately before nasal consonants (Ladefoged 2001:82). This phenomenon is so pervasive that it is even affecting the spelling of <than> as <then>. The process of raising / æ / before nasals is now complete, but / æ / is now rising in other phonological environments. Ladefoged and Disner (2010:44-45) report that / æ / is raised to / ɛ / in many northern metropolitan areas such as Detroit, Rochester, and Pittsburg. The examples they provide show that / æ / is raised to / ɛ / before / d /, as when <bad> is pronounced <bed>. In CMnE, / æ / raising also occurs, but only in the environment below:

/ æ / → [ɛ] / — [+velar, + voice][7]

The rule states that / æ / is raised to / ɛ / before / g /. Thus, words such as <*hag, bag, nag, flag, Mag, sag, lag, gag, Prague*> are pronounced < *heg, beg, neg, fleg, Meg, seg, leg*, *geg, Pregue*> respectively. The word <hag> was included in the test items so as to verify and quantify / æ / raising. The data in Table 5 shows clearly and unambiguously that / æ / raising has taken place in CMnE.

Dialects	**[ɛ]** vs.	**[æ]**	**Distance**
GAE	610 Hz	860 Hz	250 Hz
MWE	731 Hz	669 Hz	62 Hz[8]
CMnE	754 Hz	848Hz <had>	94 Hz
CMnE	754 HZ	655 Hz <hag>	99 Hz

Table 5: The Raising of [æ]

In words such <*hag, bag, nag, flag, Mag, sag, lag, gag, Prague* >, / æ / is indeed raised to / ɛ / by as much as 193 Hz, that is, (848 Hz-655 Hz). So, when Central Minnesotans say <*hag, bag, nag, flag, Mag, sag, lag, gag, Prague* >, they indeed sound like <*heg, beg, neg, fleg, Meg, seg, leg*, *geg, Pregue* > to outsiders. The reason for this is because the F1 of / ɛ / in GAE is 610 Hz. The F1 of raised / æ / in CMnE is 655 Hz. Confusion is likely between the raised / æ / of CMnE and the "normal" / ɛ / in GAE because the acoustic distance between the two is 45 Hz (655 Hz-610 Hz). Spelling data from elementary school children underscore this confusion. Many of them spell <bag> as <beg>. Many CMnE speakers have told me anecdotes about being made fun of or being misunderstood in other parts of the country because of their raised / æ /. During an informal gathering of acquaintances of mine to discuss my findings, many residents told me that they did not know how they could produce / æ / in words such as <*hag, bag, nag, flag, Mag, sag, lag, gag, Prague* > without grimacing and looking silly!

CMnE speakers perceive a difference between "normal" / æ / and their raised / æ / because they hold them distinct in different environments. Except for when / æ / occurs before / g /, their normal / æ / sounds identical with the one in GAE because there is only

[7] Cameron (2006:114) writes that in Chicago, <Mack> is pronounced <Meck>. So, it seems that / æ / raising there also occurs before the voiceless velar / k /.
[8] Flanigan (2006:121) notes that <bad> and <cat> are pronounced more like <bed> and <ket>.

a difference of 12 Hz (860 Hz-848 Hz) between them. So, even though Catford (1987:89) rates the relative functional load of / æ / and / ɛ / at 50%, widespread unintelligibility is not expected because the raised / æ / occurs only in a tiny number of words. Yet, occasional misunderstandings are likely between CMnE talkers and GAE hearers if the discourse is not redundant enough. For instance, when Governor Pawlenty was appointing his cabinet secretaries, he announced the name of his “Egg” secretary. It took me a while to realize that he meant “AG” (agriculture) secretary.

6.2 The Raising of [e] in Central Minnesota

Most vowel charts of GAE classify [e] as a mid vowel and [ɪ] as a high vowel (Fromkin et al. 2014:207). In both GAE and the Midwest, [ɪ] is a high vowel, and [e] is a mid vowel, as shown in Table 6. However, in Central Minnesota, the two vowels are flipped: [e] has risen above [ɪ] by 65 Hz (573 Hz – 508 Hz). Ladefoged (1999:41-42 describes the vowels of a 21-year-old Southern California speaker in whose idiolect [e] is raised above [ɪ]. Evidence for the raising of [e] over [ɪ] is found in the pronunciation of <milk> and <pillow> that some residents pronounce respectively as <melk> and <pellow>. Bowie and Morkel (2006:145) note that this pronunciation is also heard in Utah.

Dialects	**[ɪ] vs.**	**[e]**	**Distance**
GAE	430 Hz	NA	NA
MWE	483 Hz	536 Hz	53 Hz
CMnE	573Hz	508 Hz	65 Hz

Table 6: The Raising of [e]

Peterson and Barney (1952) did not measure / e /, so it is impossible to assess how GAE hearers are likely to perceive CMnE in relation to / ɪ /. Other Midwesterners are more likely to confuse / ɪ / and / e / than are Central Minnesota speakers because the acoustic distance between the two segments is smaller in MWE than in CMnE. Catford (1987:90) rates the relative functional load of / ɪ / and / e / to be 80%. However, since the acoustic distance between them is over 65 Hz (573 Hz-508 Hz), unintelligibility is possible but so far it is only marginal. Even with the reduced acoustic distance of 53 Hz in MWE, / ɪ / and / e / are confused only .5% of the time. Koffi (2013) has hypothesized that hearers may also rely on the phonetic feature [± ATR] in perceiving vowels. This may explain why the confusion rate of / ɪ / and / e / is negligible since the acoustic distance between them is lower than 60 Hz.

6.3 Vowel Merger in Central Minnesota

Mergers happen when two or more phonemes lose their distinctive functions and come to be pronounced and perceived acoustically as the same. Such is the story of the / ɑ / and / ɔ / that have merged into [ɑ] in Central Minnesota, as indicated in Figure 3:

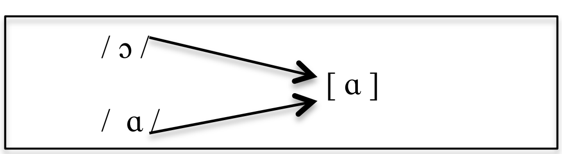

Figure 3: Vowel Merger

The merger rule is stated this way because Central Minnesotans prefer / ɑ / over / ɔ /. Ladefoged (2006:89) has made a similar observation for California speakers. The acoustic data in Table 7 shows that the merger is not complete in some dialects. Small (2005:74) reports that, "In the Midwest, the western United States, and New England, the production of this phoneme (/ ɔ /) is more variable. Some speakers from these regions use this vowel; others do not." This is in line with what Hillenbrand et al. (1995) found for the Midwest. The merger is not complete in some parts of the Midwest because the acoustic distance is 155 Hz. However, in Central Minnesota the merger is complete because the acoustic distance between / ɑ / over / ɔ / is 4 Hz, that is, 855 Hz-851 Hz, as shown in Table 7:

Dialects	**[ɔ] vs. [ɑ]**		**Distance**
GAE	590 Hz	850 Hz	260 Hz
MWE	781 Hz	936 Hz	155 Hz
CMnE	851 Hz	855 Hz	4 Hz

Table 7: The Merger of [ɑ] and [ɔ]

As a result, when speakers from Central Minnesota produce <tot> vs. <taught>, or <cot> vs. <caught>, hearers from other parts of the country would not detect any difference at all between / ɑ / and / ɔ /. My findings about the complete merger of / ɑ / and / ɔ / are supported by the information in the Phonological Atlas of North America. The researchers who produced the map found that Central Minnesotans pronounce and perceive / ɑ / and / ɔ / identically.

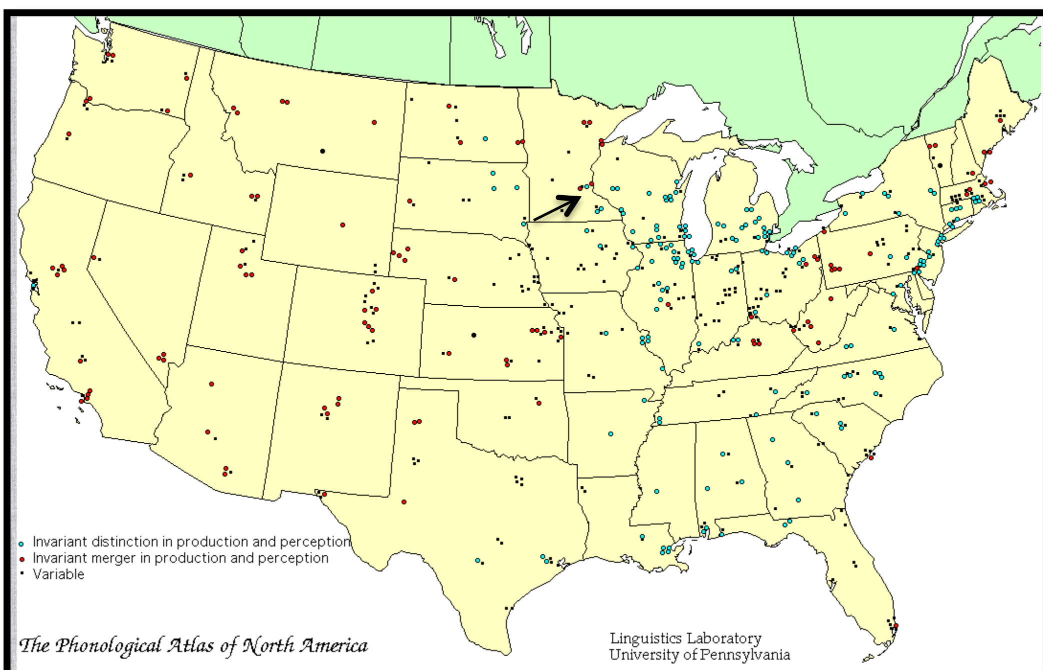

Figure 4: /ɑ/ and /ɔ/ Merger Map

Peterson and Barney's data shows that there are parts of the country where the distinction between / ɑ / over / ɔ / is still made because the acoustic distance between them is 260 Hz.[9] Figure 4 shows that from Iowa down and in many states in the South, as well as the South East, the distinction is still made.

6.4 Vowel Lowering in Central Minnesota

The pronunciation of / ʊ / is undergoing changes. Ladegofed (2006:90, 219) notes that it is unrounded and is often pronounced with spread lips in parts of the country. Where this is the case, the F2 value of / ʊ / is as high as 1500 Hz. The data in Table 8 shows this to be the case in CMnE. The mean F2 of / ʊ / is 1519 Hz. It is fronted by 294 Hz compared to MWE (1519 Hz-1225 Hz), and by 359 Hz (1519 Hz-1169 Hz) compared to GAE. Furthermore, CMnE / ʊ / is lower than its counterpart in MWE by 107 Hz (626-519 Hz), and lower than / ʊ / in GAE by 156 Hz (626 Hz-470 Hz). The vowel / ʊ / is by far the most innovative phonological event taking place in Central Minnesota. Ordinarily, / ʊ / is described as a high, rounded, lax vowel. However, in Central Minnesota, it is now a mid, unrounded, lax vowel. Data from Ewins (2012:75), Feero (2012: 85), and Glynn (2012:108) confirms this classification. In their pronunciations, the F1 of / ʊ / is respectively 691 Hz, 661 Hz, and 690 Hz, and its F2 is 1634 Hz, 1526 Hz, and 1661 Hz.

Dialects	**[ʊ] vs. [ʌ]**		**Distance**
GAE	470 Hz	760 Hz	290 Hz
MWE	519 Hz	753 Hz	234 Hz
CMnE	626 Hz	743 Hz	117 Hz

Table 8: The Lowering of [ʊ]

The lowering and centralizing of / ʊ / causes it to interfere with the acoustic space of / ʌ /. Since the acoustic distance between / ʊ / and / ʌ / is still greater than 60 Hz, confusion is, theoretically, not likely. Also, since the relative functional load between them is only 9% according to Catford (1987:90), widespread unintelligibility is not expected between CMnE talkers and GAE or MWE hearers. I have, however, come across a few instances where / ʊ / and / ʌ / have been confused. So, I have done some informal testing with Dragon Dictate, a speech recognition app. I have asked acquaintances to read the sentence *"Ladefoged gave a book and a buck to his friend."* The test items are <book> and <buck>, but I added the noun <Ladefoged> as a distractor. The results of the test are mixed. For some speakers, the software fails to discriminate between <book> and <buck>. For others, the software recognizes the two sounds accurately. The confusion of / ʊ / with / ʌ / is an emergent phonological trend worth tracking. Peterson and Barney (1952:182) found a confusion rate of 2.6% of the time for the / ʊ / and / ʌ / pair in GAE. Hillenbrand et al. (1995:3108) reported a total confusion rate 4.2% in MWE. Small (2005:79) writes that "[college] students often confuse / ʌ / with / ʊ /." No confusion data is available for CMnE, but given the extraordinary

[9] Though the merger between / ɑ / and / ɔ / seems complete, [ɔ] is still heard before liquids. So, in words such as <fall, sore, core, mall, four, call>, / ɔ / is heard.

narrowing of the acoustic distance between / ʊ / and / ʌ /, a greater rate of confusion between the two is to be expected.

7.0 Summary

CMnE is similar to GAE and MWE in two respects, and dissimilar with them in two other respects. In all three dialects, / æ / raising occurs. However, in CMnE, / æ / is raised only before / g /. It is raised so high that it interferes acoustically with / ɛ /. In all three dialects, / ɑ / has more or less merged with / ɔ /. However, in CMnE the merger is now complete. CMnE is dissimilar with GAE and MWE in that / e / has risen over / ɪ / in Central Minnesota. Peterson and Barney (1952) and Hillenbrand et al. (1995) did not attest this change for GAE and for MWE. Last, and perhaps most importantly, / ʊ / has dropped significantly and has centralized somewhat CMnE. As a result, it is interfering acoustically with / ʌ /. In spite of these variations, CMnE is highly intelligible to GAE and MWE hearers because these innovations are phonologically predictable or they affect vowels that have very low functional loads.

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